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PACKAGING AND HANDLING ANALYSIS OF A POLYETHYLENE, REUSABLE, LO--ETC(U)
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PACKAGING AND HANDLING ANALYSIS OF A

POLYETHYLENE, REUSABLE, LOW FRAGILITY, SHIPPING CONTAINER

HQ AFALD/PTP
AIR FORCE PACKAGING EVALUATION AGENCY
Wright-Patterson AFB OH 45433

August 1978

NOTICE

ABSTRACT

This study involved the evaluation of a low fragility shipping container (LFSC) developed by the Navy under contract with the Mercury Plastics Corporation to ship fragile avionics equipment. The Air Force Packaging Evaluation Agency (AFPEA) evaluated this pack (P/N 15024-200, NSN 01 016 3452) to determine if it was suitable for shipping fragile inertial guidance components. It was determined that this container would provide reasonable protection for fragile items if recommended procedures are followed regarding the positioning and securing of items on the load platform. This evaluation included low temperature (-40°F) drop test performance. Shock levels recorded in this study differed appreciable from those previously reported by the contractor but were still considered to be acceptable within limitations.

LEVEL II

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INTRODUCTION

Oklahoma City-Air Logistics Center, the Aerospace Guidance and Metrology Center and this Agency expressed interest in using the Navy's low fragility shipping container (LFSC) for shipping the LN-12 Inertial Platform, the KT-73 Inertial Measurement Unit, the AR/AN-101 Inertial System and similar inertial guidance components because of the damage potential associated with currently used packaging systems.

This Agency evaluated the adequacy of this pack for the LN-12 Inertial Platform, the LN-14 Platform Module, the LN-15 IMU and the KT-73 IMU.

In addition to the drop test heights prescribed in the test standards, heights up to 48 inches were included in this analysis for comparison with drop test data previously obtained on the currently used LN-12 fiberboard packs. The 48-inch drop height was also used to simulate toppling from storage stacks and accidental drops from a truck bed.

DESCRIPTION OF TEST PACK

The container assembly consists of a polyethylene two piece container shell with the top cover secured with ten lock type fasteners. An equipment mounting platform is supported by six flexible steel shock mounts secured to the inner bottom surface of the container. Additional information is provided in Table 1. A photograph of the test pack is shown in Figure 1.

Nominal Dimensions (O.D.) (Inches)			WT	LOAD RANGE		NR OF AEROFLEX SHOCK	NR OF PLATFORM STRAP	PLATFORM DIMENSIONS (INCHES)		
L	W	H	(LBS)	(LBS)	COLOR	ISOLATORS	ASSEMBLIES	L	W	H
35	30	29	72	8-40	Gray	6	2	19½	14	1

Table 1. Test Pack Description

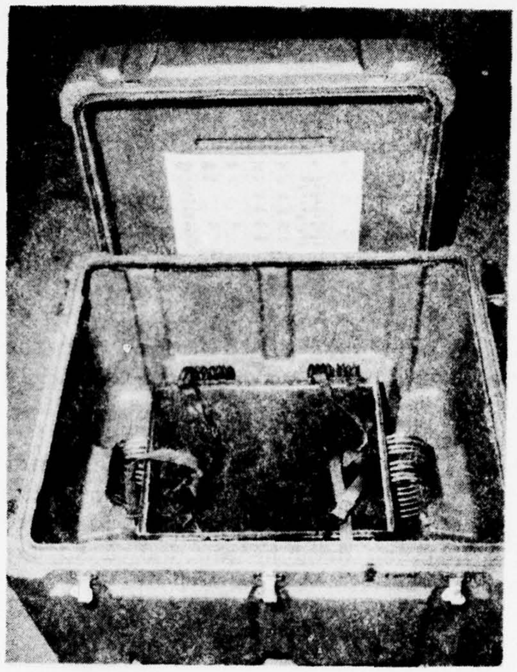


Figure 1. Test Pack

Instrumentation and Equipment

The following instrumentation and equipment were employed in this study:

Instrumentation:

1. Oscilloscope, 4 channel storage, Tektronix Model 564-B.
2. Accelerometer, tri-axial, Endevco, Model 2622C.
3. Amplifiers (3 ea.), Endevco, Model 2614C.
4. Power Supply, Endevco, Model 2622C.

Equipment:

1. Electrodynamic Vibrator, Unholtz-Dickie, Model 506.
2. Vibration Test Machine, L.A.B. Corp., Type 5000-96B.
3. Low-Temperature Test Chamber, Tenny Engineering, Inc.
4. Chain Hoist, electrical.

The drop test apparatus is shown in Figure 2.

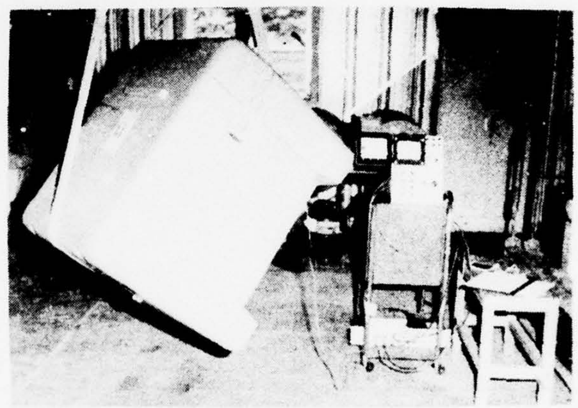


Figure 2. Drop Test Apparatus

Test Procedure/Results

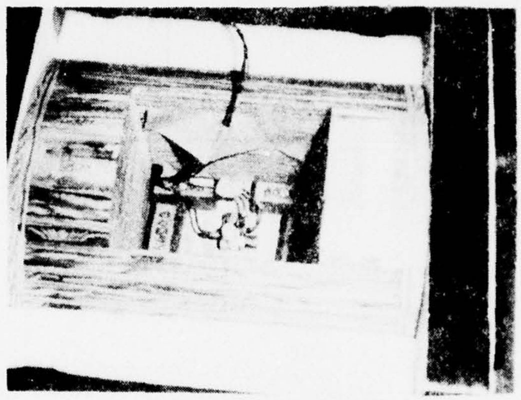
The pack was subjected to vibration and free fall drop tests, except as noted, in accordance with Federal Test Method Standard 101B. Four simulated inertial platforms, (wood models), the Transportation Environment Recorder (TER) and Inertial Measurement Units (IMU) used as test loads are shown in Figure 3. The test load weights and dimensions are listed in Table 2.

Figure 3. Test Loads

TYPE LOAD	TEST LOAD WEIGHT (LBS)	TEST LOAD DIMENSIONS (INCHES) L	W	H	CARRYING CASE WEIGHT (LBS)	CARRYING CASE DIMENSIONS (INCHES) L	W	H
TER	8	6	6	6	-	-	-	-
KT-73	20	12	7	9	5	16	11	11
LN-14	30	14½	11	10	-	-	-	-
LN-12	32	14	10	11	3	18½	14½	14¼
LN-15	39	13	8½	14	-	-	-	-

Table 2. Test Load Information

All drop test and vibration test data were obtained using a tri-axial accelerometer located at the center of gravity of each test load as shown in Figure 4. The accelerometer on the TER load was located off-center because of interference with the recorder.



Valid data were recorded for 190 of the 200 drops. The shock duration varied between 20 and 100 milliseconds for this drop test series.

Sinusoidal Vibration Test - Method 5020 (test pack strapped to vibration table)

The sinusoidal vibration test data obtained with the LN-12 simulated load (32 lbs) are shown in Table 3. During the test procedure, the relatively flexible side walls of this container vibrated excessively in the 70 HZ range indicating that the container shell has a resonant frequency in this range. During the frequency sweep from 60 to 80 HZ, the vibration response of the test load was 1G at 60 HZ, 3G's at 70 HZ and 2 G's at 80 HZ.

INPUT FREQUENCY (HZ)	DURATION (MINUTES)	TABLE DISPLACEMENT (DOUBLE AMPLITUDE) (INCHES)	RESPONSE ACCELERATION PEAK TO PEAK (Gs)
2	5	1	0.5
3	5	1	1.2
5	5	1	3.0
6-500	45	.036-.673	3.0

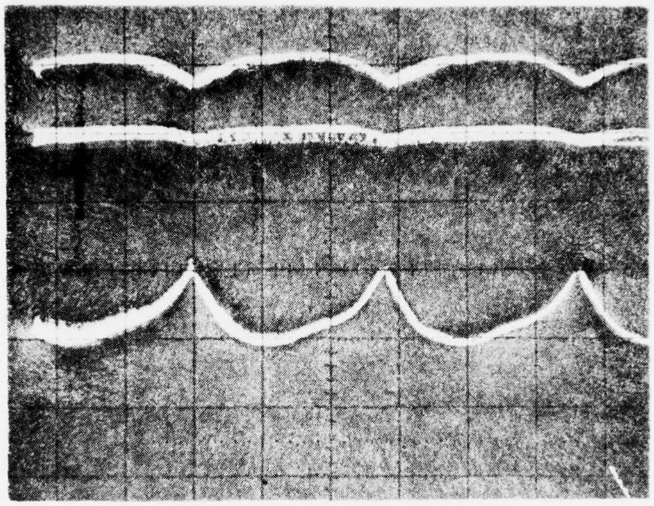
Table 3. Sinusoidal Vibration Test Data (LN-12)

Resonant Frequency Test

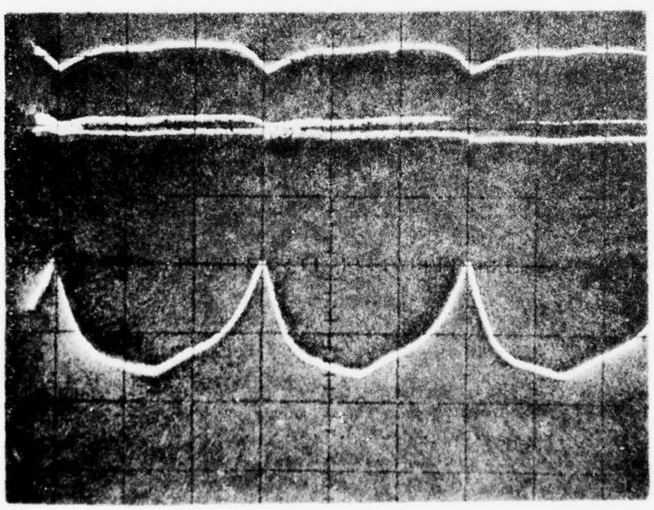
The resonant frequency of the shock isolation system (platform assembly) was 3.2 to 3.5 HZ. This data is shown in Table 4 together with the data generated at the end of a 15-minute period of continuous vibration at the resonant frequency. The data were obtained from the oscilloscope traces shown in Figure 5. No damage resulted from these tests. However, two fasteners came loose during the test cycle.

RESONANT FREQUENCY (HZ)	TABLE DISPLACEMENT (DOUBLE AMPLITUDE (INCHES)	RESPONSE (PEAK TO PEAK) ACCELERATION (RESULTANT Gs)	TRANSMISSIBILITY FACTOR
3.5 after 1 minute	1	6.5	5.16
3.2 after 15 minutes	1	8.3	7.98

Table 4. Resonant Frequency Data (LN-12)



(a) After 1 Minute of Vibration
5Gs/cm (vert.), 0.1 sec/cm (horz.)



(b) After 15 Minutes of Vibration
5Gs/cm (vert.), 0.1 sec/cm (horz)

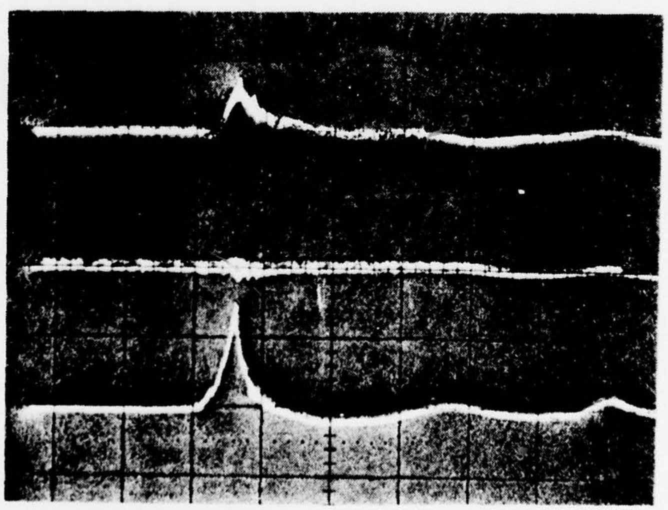
Figure 5. Oscilloscope Traces at Resonant Frequency

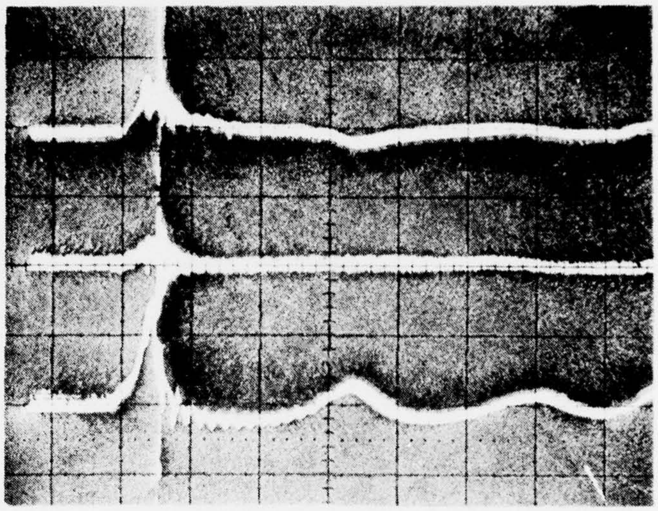
Repetitive Shock Vibration Test - Method 5019 (unrestrained load)

The repetitive shock vibration test was conducted without incident. The shock response of the test load varied between 3.5 and 3.8 Gs. The input frequency used was 3.5 HZ. After this two-hour test, the simulated LN-12 test load was positioned off-center on the container platform and was vibrated at the same frequency. The maximum shock response of the test load increased to 4.2 Gs. No damage resulted from the repetitive vibration test and all the container fasteners remained secure.

Free Fall Drop Test - Method 5007, Level A, Procedure B and C

During the preliminary drop test series, extremely high level, short duration shock pulses were generated by the 18 and 21-inch drops. Three independent drop test series were conducted by different investigators and the results in each case were similar. Initially, it was thought that the pulse spikes were caused by transient electrical signals in the instrumentation. However, it was determined by test and observation that the container platform was "bottoming out" on some of the drops. This problem was caused by the load shifting off-center on the platform on all but the top and bottom face drops. The oscilloscope traces of this effect are shown in Figure 6.





(b) Pulse Spikes due to "bottoming" (edge drop)

Figure 6. Oscilloscope Traces of "Bottoming Out" Effect

To correct this situation, two 3/8 inch thick vinyl-rubber pads (Figure 7) were positioned under each test load. By applying high tensioning forces on the restraining straps, the pads were partially compressed and prevented slippage on the hard rubber covered platform.

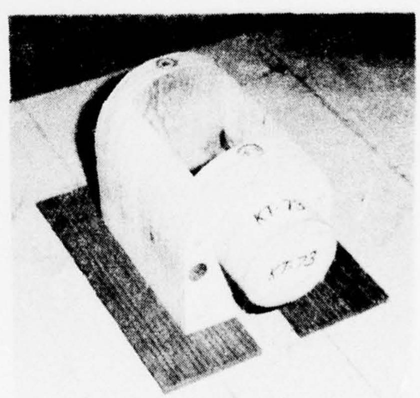


Figure 7. Vinyl-Rubber Pads

When the load is off-center, the shock isolator coil makes contact with the isolator retaining brackets producing high level shocks which exceed the fragility rating of the guidance components tested. To reduce this type of shock input, a 1/4-inch thick piece of polyethylene material was secured to each of the 12 retaining brackets with masking tape.

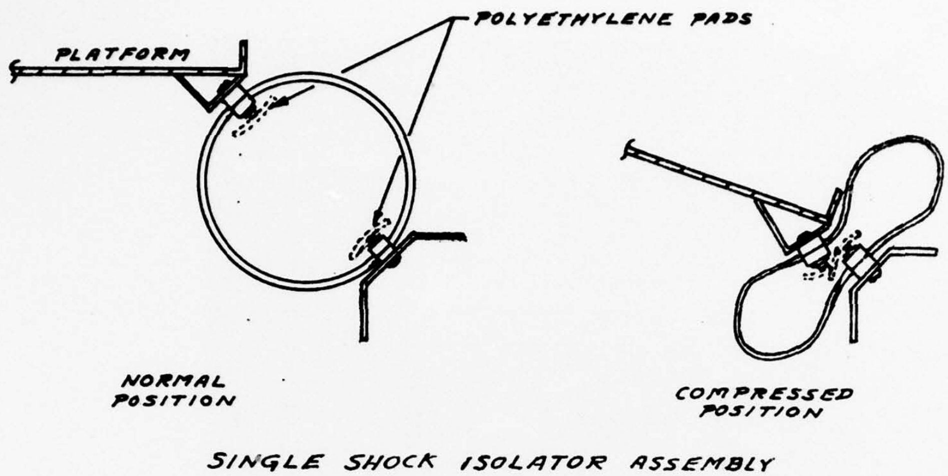


Figure 8. Sketch of Shock Isolator and Polyethylene Pad

The pad position is shown in Figure 8. This produced the evidence of bottoming shown in Figure 9.

The wire coil caused the small holes in the tape and the protuding bolts punctured the tape and the polyethylene as shown circled with dash lines. The small holes were darkened with black ink to improve the photographic contrast.

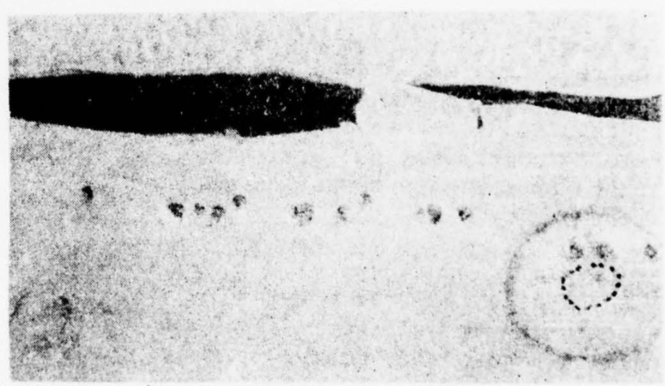


Figure 9. Photograph of Punctured Polyethylene Pads

To demonstrate this effect, Figure 10 shows the isolators being manually compressed. These polyethylene pads were removed for the standard tests.

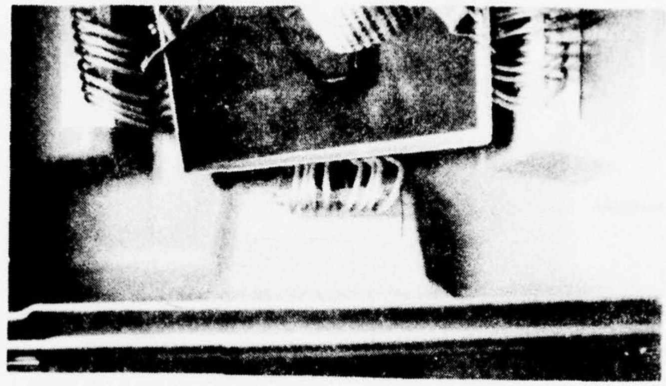
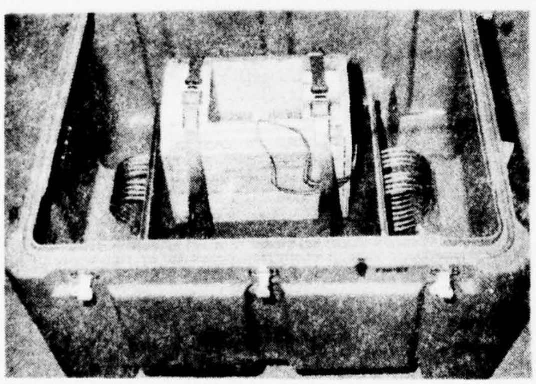
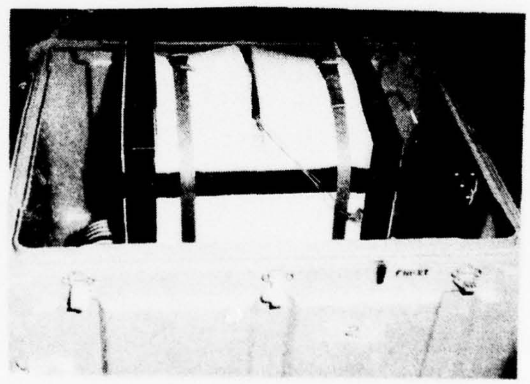


Figure 10. Manual Compression of Shock Isolator

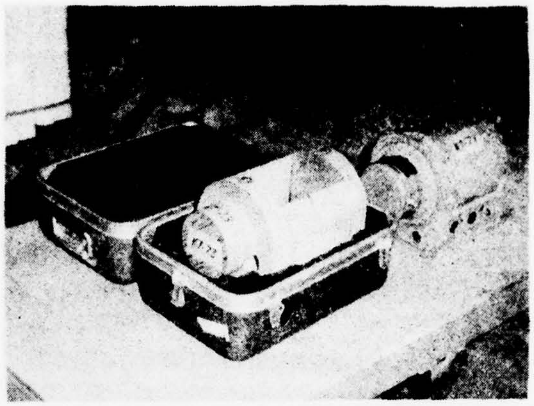
Drop tests were made with the LN-12 and the KT-73 test loads with and without a carrying case or protective covering as shown in Figure 11. The LN-12 protective cover was fabricated from 2-inch thick, 2 lbs/ft^3 polyethylene. The thickness of the top piece was reduced to one-inch to maintain the proper clearance between the item and the container walls. The KT-73 carrying case is standard for the pack currently being used to ship this item.



(a) LN-12 Without Protective Case



(b) LN-12 With Protective Cover



(c) KT-73 With Carrying Case

Figure 11. LN-12 and KT-73 Polyethylene Cover and Carrying Case

In Table 5, the results of the 18-inch free fall drop tests of the KT-73 and the LN-12 test loads with and without a protective cover are compared to the drop test results obtained by the Aeroflex Corporation (Aeroflex report nr. ASO P/N 15024-200). Note that the Aeroflex data are shown for a drop height of 30 inches, whereas AFPEA's data were generated from a drop height of 18 inches as specified in Federal Test Method Standard 101B. Aeroflex's supplementary drop test data (9 January 1978) included a 18-inch drop with a 10-pound load. The ten consecutive drops on the top face averaged 12 Gs for this supplementary test.

IMPACT SURFACE	PEAK ACCELERATION (Gs)				
	AEROFLEX, 30" DROP (35# LOAD)	AFPEA: 18" DROP (RESULTANT VALUES)			
		KT-73		LN-12	
		20# LOAD w/o case	25# LOAD w/case	32# LOAD w/o cover	35# LOAD w/cover
3 (BOTTOM)	7	6.8	8.1	6.2	10.4
1 (TOP)	13	34.4	28.0	24.1	34.4
2 (FRONT)	9	12.4	12.2	9.1	12.0
4 (BACK)	8	14.3	14.6	10.4	15.3
5 (L. SIDE)	7	12.5	12.6	12.1	12.2
6 (R. SIDE)	7	15.0	14.0	13.4	17.5
3-4-6 (BOTTOM CORNER)	7	12.1	15.3	12.7	18.5
3-6 (BOTTOM EDGE)	7	14.3	13.7	13.0	11.4
3-4 (BOTTOM EDGE)	7	11.4	11.7	12.7	12.7
4-6 (BOTTOM EDGE)	5	19.8	16.4	16.3	15.1
AVERAGE	8	15.3	14.7	13.0	16.0

Table 5. Comparative Drop Test Data

The shock value difference may be the result of their using a low band pass filter which prevented the pulse spikes from being recorded and the use of a single accelerometer in place of a tri-axial accelerometer. Their test load was protected with a foam cover.

Partial drop test data for the 8-pound (TER), the 30-pound (LN-14) and the 39-pound (LN-15) test loads are presented in Table 6. These test loads did not include protective covers or carrying cases.

IMPACT SURFACE	PEAK ACCELERATION (Gs)		
	TER 8# LOAD	LN-14 30# LOAD	LN-15 39# LOAD
3 (BOTTOM)	7	8.9	13.2
1 (TOP)	28.5	27.0	33.2
2 (FRONT)	15.4	12.0	20.8

Table 6. Additional Test Load Data

The eight pound test load drop test series revealed some interesting results. Since the TER has the capability of recording during the entire input period not only the initial shock but all rebound shocks and shock excited vibrations were recorded for a series of ten drops. The peak acceleration outputs of the external tri-axial accelerometer was recorded on the storage oscilloscope and compared to the TER results as shown in Table 7. The total number of recorded shock inputs from the oscilloscope display was 30 compared to 207 shocks recorded by the TER.

OSCILLOSCOPE DATA	IMPACT SURFACE	SHOCK LEVEL (Gs) X	Y	Z	R
18" DROP	3	0	0	7	7
	1	MISSED			
	1	5	2	28	28.5
	2	2	15	3	15.4
	4	2	16	3	16.4
	5	12	0	4	12.6
	6	11	2	8	13.7
30" DROP	3	0	0	10	10
	1	MISSED			
	1	0	0	40	40

TER DATA							
	NUMBER OF SHOCKS RECORDED						
SHOCK LEVEL RANGE (Gs)	IMPACT SURFACE 3 BOTTOM	1 TOP	2 FRONT	4 BACK	5 L. SIDE	6 R. SIDE	TOTAL PER BIN
2.0 - 5.0	15	28	24	25	33	20	145
5.0 - 7.5	11	10	2	1	5	6	35
7.5 - 10.0	1	3	0	0	1	1	6
10.0 - 12.5	*3	2	0	0	0	3	8
12.5 - 15.0	1	0	0	1	1	1	4
15.0 - 17.5	0	0	1	0	0	0	1
17.5 - 20.0	0	0	0	0	2	0	2
22.5 - 25.0	0	1	0	0	0	0	1
25.0 - 27.5	1	0	0	0	0	0	1
27.5 - 30.0	2	0	0	0	0	0	2
42.5 - 45.0	1	0	0	0	0	0	1
50.0 - 60.0	*1	0	0	0	0	0	1

*This shock level was missed on the oscilloscope as noted

Table 7. Oscilloscope and Transportation Environment Recorder (TER) Data of Drop Test with Eight Pound Load

The design of this suspension system created a situation which differed from a typical fiberboard/cushion pack when dropped on the top surfaces. The shock isolators, which normally act in compression, are in tension for this type of drop and, therefore, produce high level shock inputs to the platform. All of the top face, top edge and top corner drops produced large shock pulses. A partial list of results is presented in Table 8. The drop height was 18 inches.

IMPACT SURFACE	PEAK ACCELERATION - G's (RESULTANT VALUES) KT-73	LN-12	LN-14	LN-15
1 (TOP)	29.2	22.4	27.0	33.2
1-2 (Top Edge)	27.5	34.4	25.6	25.5
1-5 (Top Edge)	33.5	26.9	34.3	23.5/49.0*

*"Bottoming Out" (Peak of spike)

Table 8. Drop Test Data for Top Surface Impact

Prior to the discovery of the "off-center load problem", a 21-inch drop test was conducted with the item secured to the hard rubber padded platform with normal tension applied to the straps. These results are presented to demonstrate the effect of a load which is not rigidly positioned on the center of the platform. The data in Table 9 revealed that the load will shift and produce higher than normal shock levels if the load is not centered after each drop. The pulse spikes indicated that "bottoming-out" occurred. The 32-pound LN-12 test load was used for this drop test series.

IMPACT SURFACE	PEAK ACCELERATION (Gs) X	Y	Z	R
3 (Bottom)	3	0	14	14.3
1 (Top)	2	2	28	28.1
5 (Side)	10	0	7	12.2
2 (Front)	2	4	7	8.3
4-5-3 (Bottom Corner)	20	3	20	28.4
4-5-3 (Bottom Corner)	26	8	30	*40.5
3-5 (Bottom Edge)	14	0	15	20.5
3-4 (Bottom Edge)	8	4	12	15.0
4-5 (Bottom Edge)	25	4	23	*34.2
4-5-3 (Bottom Corner)	30	9	50	*59.0

*Pulse Spikes

Table 9. Off-Center Load Effect (Drop Test)

Drop Test (Before and After Vibration)

To determine if the vibration test affected the coil spring shock isolators, drop tests were conducted after the vibration test and the data were compared to drop test data obtained prior to the vibration tests. The 20-pound KT-73 load (w/o case) was used to generate the data presented in Table 10.

IMPACT SURFACE	PEAK ACCELERATION (Gs)	
	BEFORE	AFTER
3 (Bottom)	6.8	6.3
1 (Top)	34.4	26.6
3-4 (Bottom Edge)	11.4	7.8

Table 10. Drop Test Data (Before and After Vibration)

Topple Test

Additional test data were generated for drop heights of 30 and 48 inches to simulate drops from a two high storage stack and a drop from a truck bed. The data are compared to the 18 and 21-inch drops in Table 11. The relationship between drop height and the resultant impact force is grapically summarized in Figure 12.

LN-12 LOAD IMPACT SURFACE	PEAK ACCELERATION (Gs) DROP HEIGHTS (INCHES) 18"		21"		30"		48"	
	Gs	Loose Fasteners	Gs	Loose Fasteners	Gs	Loose Fasteners	Gs	Loose Fasteners
3 (Bottom)	7.9	1	10.4	4	17.2	5	42.6	7
1 (Top)	22.4	6	28.0	7	37.1	8	48.2	*10
2 (Front)	9.5	0	12.8	0	35.9	2	20.8	0
4 (Back)	13.2	0	15.0	0	16.7	1	31.9	0
5 (L. Side)	14.8	0	20.2	0	25.7	0	--	0
6 (R. Side)	10.2	0	18.5	2	22.5	0	38.5	0
Average	13.0		14.4		22.0		36.4	

*Container top separated from the bottom section

Table 11. Topple Test Data

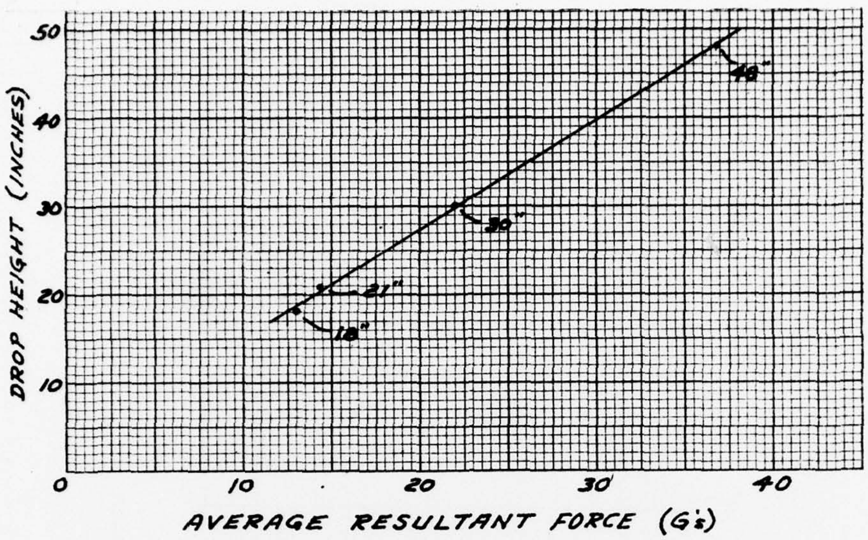


Figure 12. Plot of Drop Height Average vs. Resultant Forces

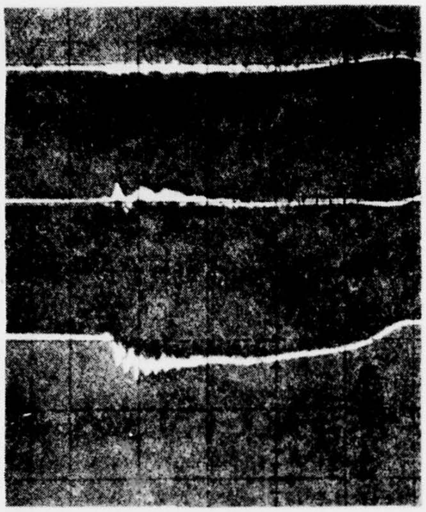
Low Temperature Drop Test

Low temperature drop tests were conducted to determine if the LFSC container would crack or shatter during rough handling in an arctic environment. For each temperature range, the chamber temperature was held constant for a period of four hours. The pack was dropped on the bottom and top surfaces while inside the chamber, however, the corner and edge drops were made outside the chamber because of limited ceiling clearance. To compensate for the heat loss (warming) during the drops, the chamber temperature was lowered an additional 10°F for an additional time period of ½ hour. Also, a different corner and edge was used for each temperature range to reduce the possibility of weakening the container prior to reaching -40°F. The data are presented in Table 12. With the exception of the 3-4-5 and the 3-4-6 corner drops, the shock levels were lower than those obtained for the ambient temperature drops. The 20-pound KT-73 test load (w/o case) was used for this 18-inch drop test series. No damage resulted from these drops.

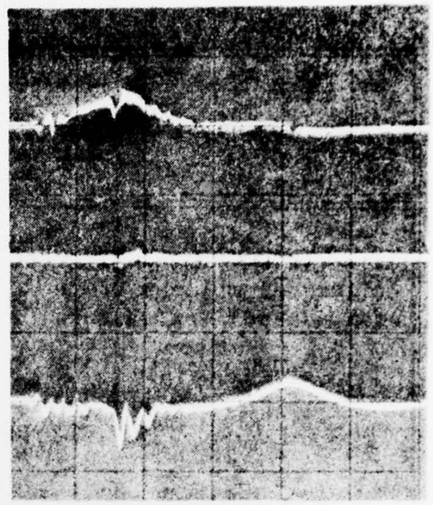
IMPACT SURFACE	PEAK ACCELERATION (Gs) TEMPERATURE RANGE AMBINET	0°F	-20°F	-40°F
3 (Bottom)	6.8	6.0	6.0	6.0
1 (Top)	34.4	26.6	26.2	25.4
2-3 (Bottom Edge)	-	-	13.0	-
4-3 (Bottom Edge)	11.4	-	-	8.7
5-3 (Bottom Edge)	-	9.3	-	-
2-3-5 (Bottom Corner)	-	-	11.2	-
3-4-5 (Bottom Corner)	-	-	-	33.5
3-4-6 (Bottom Corner)	12.1	26.7	-	-

Table 12. Low Temperature Drop Test Data

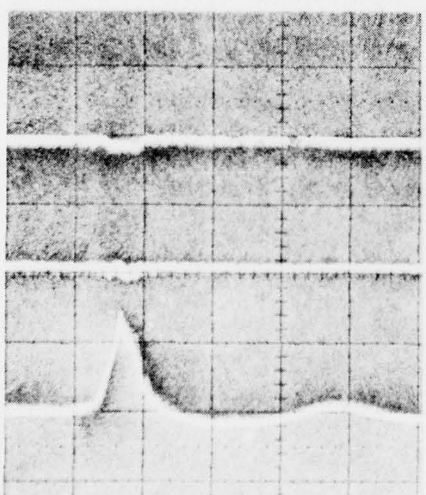
Some typical oscilloscope traces of an 18-inch drop are shown in Figure 13. Note that the bottom surface drop (a) was at 0°F while b, c and d were at 70°F. Also, the vertical scale of (a) was 10 G's/cm instead of the 20 G's/cm scale used for b, c and d.



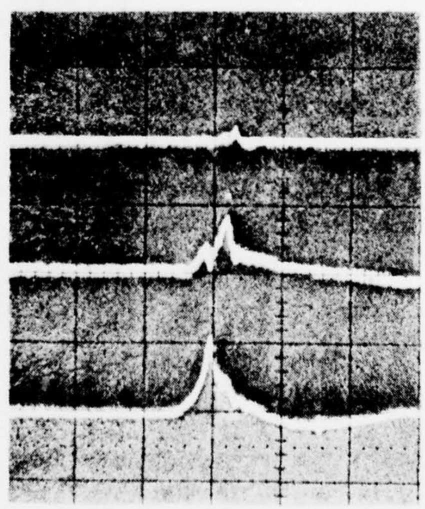
(a) Bottom Face ($0^{o}F$)
10 Gs/cm (vert)
50 msec/cm (horiz)
Resulant force = 6.0 Gs



(b) Bottom Edge ($70^{o}F$)
20 Gs/cm (vert)
50 msec/cm (horiz)
Resulant force = 14.4 Gs



(c) Top Face ($70^{o}F$)
20 Gs/cm (vert)
50 msec/cm (horiz)
Resulant force = 28.2 Gs



(d) Top Edge ($70^{o}F$)
20 Gs/cm (vert)
50 msec/cm (horiz)
Resulant force = 24.4 Gs

Figure 13. Typical Oscilloscope Traces of 18 Inch Drops

Field Test

The field test of the LFSC pack was conducted in conjunction with a previous evaluation of the LN-12 Inertial Platform (AFPEA Report No. 78-14). The transportation environment recorder was located near the center of gravity of the LN-12 test load as shown in Figure 14.

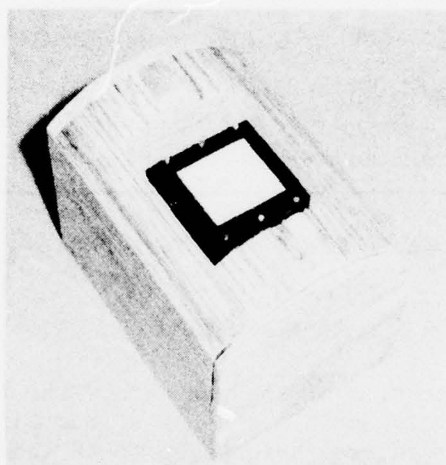


Figure 14. Photograph of Environmental Recorder

The instrumented test pack was shipped to Nellis AFB, Nevada via LOGAIR, to monitor the transportation and handling environment of the LN-12 test load. The route included stops at Dover, Robins, Kelly and Hill Air Force Bases. Data were also recorded for the return trip to WPAFB. The majority of the shock inputs recorded, resulted from transportation vibrations. The results are listed in Table 13. Comparisons are made between the LFSC pack and two types of fiberboard packs presently used to ship the LN-12 Inertial Platform.

TYPE PACK	NUMBER OF SHOCKS RECORDED	RANGE OF MAJORITY OF SHOCKS	MAXIMUM SHOCK RANGE RECORDED
A	1638	5-7½ Gs	60-70 Gs
B	75	2½-5 Gs	17½-20 Gs
LFSC	249	1-2½ Gs	2½-5 Gs
Recorded temp. range: 40-80°F (3.8 days @ 60-70°F)			
Recorded humidity range: 0-60% (4.3 days @ 30-40%)			
Recorded elapsed time: 8.1 days			

Table 13. Field Test Data

DISCUSSION

Container: With the exception of the gasket and the fasteners, the LFSC container is extremely durable and has a long life cycle potential. After 200 drops from heights up to 48 inches and the severe vibration tests, this test pack was essentially "as good as new."

Suspension System (Shock isolators): The Aeroflex isolators did not appear to weaken after these severe rough handling tests. After the initial stressing of the coils during the preliminary test phase, the performance of the suspension system actually improved. This was indicated by the fact that fewer pulse spikes appeared on the recorded pulse traces, i.e. less "bottoming-out" occurred when the load was off-center. However, this "bottoming-out" effect was not completely eliminated until the load was rigidly held in the center of the platform.

Seal: A problem with the gasket occurred early in the test program. The adhesive separated from the polyethylene groove in the container. During one of the latching sequences, the loose gasket was compressed on the outer lip of its retaining groove and was cut by the latching mechanism. Repeated bonding of the gasket was required throughout the test program.

Fasteners: As a result of impact shocks, the lip of the latch mechanism was bent out of shape and prevented positive mating of the container sections. This was considered to be a minor problem since the repairs could be made with standard hand tools (pliers, etc.).

This pack is a considerable improvement over some of the existing packs used to ship fragile guidance components; however, additional improvements are necessary to prevent high level shock inputs to the load if the pack is dropped on the top surfaces. Because of its size and weight, the possibility of this pack being dropped on the top surfaces is remote. This was verified by the field test results. A smaller and lighter fiberboard pack could be handled more severely or placed at the top of a stack where the cargo is palletized thereby, exposing it to a potentially higher drop height.

The "off-center" loading problem identified in this study could be eliminated by using a simple rigid template or a rigid inner carrying case designed to fit the platform dimensions, which would prevent slippage on the platform. A simple template for this purpose is shown in Figure 15.

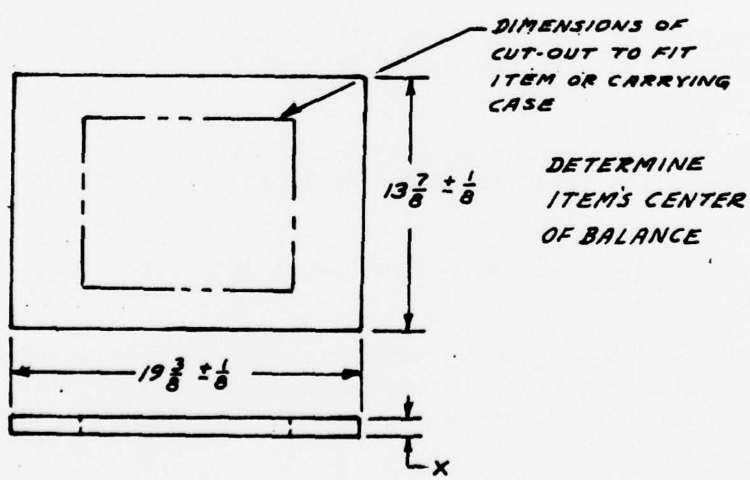


Figure 15. Sketch of Load Positioning Template

If a 9 lb/ft^3 polyethylene or similar material is used, the thickness (x) should be at least 1 inch. If plywood were used, the thickness could be reduced to ½ inch. The exact location of the center "cut-out" would be determined by considering the center of balance for each item; positioning by shape of item is not adequate.

The heavy LN-15 IMU simulated load (39 lbs) generated the highest shock level of all the loads tested. This is attributed primarily to the height of the unit rather than its weight. The higher center of gravity produced a significant "cantilever effect" when dropped on the sides, edges and corners.

CONCLUSIONS

1. The LFSC pack evaluated in this study will protect items in the 8 to 40 pound load range with a fragility rating between 15 and 20 Gs when dropped from a height up to 18 inches provided that the item is rigidly positioned at the center of balance on the platform.

2. A rigid template or carrying case with dimensions to fit the inner dimensions of the platform should be used to prevent the load from shifting on the platform.

3. If the LFSC pack is dropped on the top, the top corners or the top edges, items in the fragility range of 15 to 20 Gs could be damaged.

4. The container and suspension system have a long life cycle potential.

5. This container will adequately protect the KT-73, LN-12, LN-14 and other guidance components with similar weights, shapes and fragility, provided that the items are properly centered and secured to the load platform.

6. Because of its dimensions the LN-15 IMU cannot be accommodated by this container.

RECOMMENDATIONS

1. Include drawing of load positioning template and instructions in the Transportation Packaging Order (TPO) for proper load balance on the platform for each type of item shipped in this container. The instructions on the inner surface of the top section of the container should include mandatory use of templates for maintaining center of balance on the platform.

2. Improve the method for securing the container gasket in the gasket groove.

3. Increase the metal gauge thickness of the fasteners to prevent bending of the fastener lip.

4. If practical, make preliminary shipments of the LN-12, LN-14 and similar guidance components prior to the purchase of large quantities of this type of container.

5. Monitor the Mean Time Between Failure (MTBF) of avionics components presently being shipping in this container and compare with the MTBF for items shipped in the pack previously used.

6. If this container is procured with the recommended template, monitor the MTBF for this pack and compare it with the packs which do not incorporate a method to rigidly hold the load on the center of the platform.

7. Newark Air Force Station (AGMC) recently indicated concern about the deflection of the top surface of these containers during stacking and palletizing. Further investigation is recommended to determine the extent of the problem and its cause.

8. Based on handling problems reported by AGMC, it is recommended that consideration be given to incorporating fork lift entries in the container to prevent damage to the bottom surface.

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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Rigid polyethylene container; "Aero-Flex shock mounts; laboratory test; vibration, drop test, field test.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This study involved the evaluation of a low fragility shipping container (LFSC) developed by the Navy under contract with the Mercury Plastics Corporation to ship fragile avionics equipment. The Air Force Packaging Evaluation Agency (AFPEA) evaluated this pack (P/N 15024-200, NSN 01 016 3452) to determine if it was suitable for shipping fragile inertial guidance components. It was determined that this container would provide reasonable protection for fragile items if recommended procedures are followed regarding the positioning and securing of items on the load platform. This evaluation included low

temperature (-40°F) drop test performance. Shock levels recorded in this study differed appreciable from those previously reported by the contractor but were still considered to be acceptable within limitations.